FINAL REPORT

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Submitted by:
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SUMMARY: This grant provided support for participation by Rice University in a Key Project of the Compton Gamma Ray Observatory mission. The goal of the Key Project was initiatiion of a survey of the sky in the 0.05 - 10 MeV energy band, using the Oriented Scintillation Spectrometer Experiment (OSSE) on board Compton. Two years of support were provided, beginning 01 March 1995.

The PI for the Rice portion of the work was Prof. Robert C Haymes, who is a member of Rice's Department of Space Physics and Astronomy. At various times the grant provided partial support for Rice graduate students Matthew Huddleston, Michael Moss, Peter Walker and James Wooten.

There were two major products of the Rice research. Part One is described in the PhD thesis of Dr Michael J. Moss, dated February, 1997. The title of that thesis is "Gamma Ray Observations of Two Black Hole Candidates, GRS 1716-249 and GRS 1009-45 ." An abridged version of Part One is now being prepared for submission to the Astrophysical Journal.

Part Two is an outgrowth of the original purpose of the grant to Rice, which was to help devise an optimal survey strategy for OSSE. As it became apparent that at most very few sources of gamma-ray spectral lines were going to be discovered by Compton, it was realized that all possible causes for this unexpected apparent scarcity should be explored. One possibility is that unevaluated systematic errors contribute to the scarcity. Part Two is a study of some of the systematic errors of the MeV-band instruments on board Compton. Entitled "PASS: Prometheus All Sky Survey," it appears on the World Wide Web, at the Universal Resource Locator <http://spacsun.rice.edu/~moss/pass.html>.

(Its most recent edition is dated 22 February 1997.)

Abstracts of the two Parts appear below.

ABSTRACT OF PART ONE:

Results of spectral analysis and time series analysis of the transient source X-ray nova Velorum 193 (GRS 1009-45) and X-ray nova Ophcuhus 1993 (GRS 1716-249) are presented. These data were accumulated using the OSSE low-energy gamma-ray experiment on the Compton Gamma Ray Observatory.

Spectral observations of the two X-ray novae showed the presence of a gamma-ray emission to greater than 100 keV, which is a typical signature of a binary system with an accreting black hole. Observations of GRS 1009-45 show that it was in a gamma-ray soft state during the one-day OSSE observation, which occurred during the exponential decay phase of outburst. The spectrum of GRS 1716-249 acquired during the plateau stage of outburst indicated a hard state, while spectra acquired during the sawtooth outbursts suggest a hard to soft transition occurs as the decay progresses. The 40-200 keV pre-outburst luminosity of GRS 1716-249 is shown to be two orders of magnitude less than that estimated during the plateau-stage observation.

The only significant power spectrum was that acquired for GRS 1716-249 during the plateau stage of outburst. It is consistent with the sum of two Quasi-Periodic Oscillation (QPO) peaks at 0.128 and 0.32 Hz, and a red noise (ν^{-1}) component. This power spectrum is consistent with other black hole candidate power spectra for which the source is in the low state. Power spectra for GRS 1009-45 and GRS 1716-249 during the peak of a sawtooth outburst are also presented. They are consistent with band-limited white noise. Corresponding autocorrelations are shown for all observations.

ABSTRACT OF PART TWO:

Given the sensitivities of the COMPTEL and of the OSSE on board the Compton Gamma Ray Observatory (CGRO), about 16 astronomical discrete sources of gamma-ray spectral lines would have been expected to be Compton - detected by now. However, only two, the Cas A supernova remnant and the complex of giant molecular clouds associated with the Orion Nebula, have been

reported, both by the COMPTEL team. It is worrisome that OSSE has not confirmed even these two. As a result of the research supported by the grant and related investigations, two tests are proposed of the hypothesis that instrumental systematic errors are responsible for the relative lack of discoveries. In one test, OSSE would re-measure one of the two, but with its detectors unmoving with respect to the spacecraft. The CGRO would instead be maneuvered to accomplish the necessary pointings. In the other test, an all-sky survey, called PASS, would be conducted. PASS would use an instrument, Prometheus II, that is different from either OSSE or COMPTEL. While CGRO is still on orbit and before the launch of INTEGRAL, PASS should conduct its survey throughout the 0.1 - 10 MeV gamma ray energy interval. It is to use two flights of Long Duration Balloons that carry the Prometheus II instrument. The balloon flights will be in the northern and southern hemispheres, respectively. On each balloon flight Prometheus II is to be tilted at a constant zenith angle while it executes continuous azimuthal rotation about the vertical. At 1 MeV energy, PASS will have a limiting sensitivity of 2×10^{-5} cm^{-2} sec^{-1} for spectral lines, with 5% energy resolution and half-degree angular resolution.